

MECHANISM FOR NESTED EXPANSION OF DATA COLLECTION

Technical Field

The present invention relates to the field of determining information from multiple computers connected on a system. More specifically, the present invention relates to the gathering of information utilized on a system based on a Common Information Modeling (CIM) standard.

Background

Commonly, pluralities of computers, databases, printers and other computing or computing related devices are often established in clusters, as members or elements of a network, or even as loosely defined connections (which may be permanent or temporary) of computers and/or computing devices. Such configurations shall hereafter collectively be identified as a Cluster. Similarly, those computing devices establishing the connections between and with other such devices shall be defined as Nodes. Further, it is commonly appreciated that various virtual and/or real devices and components are often utilized in and/or accessed by a computing device (for example, printers, hard drives, monitors, software applications and others). For purposes of the present discussion, such devices are herein identified as Resources. Such Resources are generally accessible and/or utilized via other systems and devices, and/or users of such systems and devices via Nodes on a Cluster. Such users (which may be human or automated) are herein collectively defined as Clients. As such, it is commonly appreciated that Clients, via Nodes on Clusters, often utilize and need information pertaining to all the Resources or specific types or instances of Resources accessible to the Client.

Since Clients often desire to know what type of Resources are accessible via a given Cluster, various software devices have been developed that enable Clients to obtain information pertaining to a Resource, a Node, a Cluster or a combination thereof. Such devices are often called Object Managers (OM). More specifically, standardized OMs have been developed, including for example, the Common Information Modeling standard (CIM). The CIM standard for OMs was created by a consortium of industry companies and can be found at <http://www.dmtf.org>. It is commonly appreciated that CIM and WBEM are extremely similar, as such CIM is herein defined to also include WBEM.

The CIM standard outlines the basic architecture for a CIM compliant OM (CIMOM) but does not enforce any implementation details. As is commonly appreciated,

CIM enables application developers to code their Client's applications so that they may interact with the CIMOM using a predefined, platform independent, set of Application Program Interfaces (APIs). This basic CIM architecture enables a CIMOM to startup and load any CIM compliant Resource via a Provider, wherein a Provider is a piece of software code that will call whatever routines are needed to gather data in order to provide the necessary objects in a schema. Those skilled in the art appreciate that a schema is an abstraction of something that exists in the real world. As such, in CIM, a schema is a group of classes (collections or sets of objects) that have only one owner. For example, a collection of disc drives might have an owner identified as a specific database, i.e., a Resource, that is connected to the Cluster and is accessible via the associated Provider.

Each Provider is suitably configured to extract information from the various objects with which it may be associated. For example, in a multi-disc or tape database, a database Provider is configured to obtain necessary information from each object in the database. Such information might include available memory, file allocations, and other information. There are often hundreds if not thousands of Providers on a given Node and/or Cluster. Provider writers commonly come up with a schema of what they are going to provide, and then code their respective Providers to provide such objects upon request. The CIM standard defines those APIs utilized to interact and extract information from a Provider. These standards are utilized by Provider writers.

As such, it is to be appreciated that a pre-defined methodology exists for identifying information about a Resource, a group of Resources, or even a sub-set of a Resource to an OM under the CIM standard. Under these standards, each CIMOM is configured such that it can determine which Provider is providing the desired information (for example, the amount of available memory in a database). Further, the CIMOM is configured to “ask” for and receive such information from a Provider. However, the CIM standard does not specify how information from Providers is to be obtained. Since Cluster managers often desire Cluster-wide configuration and Resource information, an approach is needed to determine how Resources are configured on a Cluster using Providers and requests from CIMOMs.

One common methodology by which a Client CIM can obtain Cluster-wide information concerning Resources is shown in Figure 1. As shown, this prior art process basically entails having the Client CIM contact every Node on the Cluster. As can be readily appreciated, this approach requires numerous connections between the requesting

Client CIM 102 and a plurality of Node CIMOMs (110, 112, and 114) on Nodes A, B and C (104, 106 and 108, respectively). In turn, each of the Node CIMOMs, may have multiple Providers connected thereto (for example, Providers A and B, i.e., 116, 118, 120, 122, 124, and 126). For even a simple three Node example, where each Node possesses two Providers (as shown in Figure 1), the request from the Client CIM 102 over the communications network 128 entails requests to three separate Node CIMOMs, which may end up requesting information from six Providers. In an extremely large system, wherein hundreds if not thousands of Nodes may exist, this approach can be extremely time and Resource consuming. This may be especially true when the Client CIM 102 can only contact one Node at a time and, thus, is forced to contact each Node on a Cluster in a serial manner. Further, since the network connection 128, in certain embodiments, may not be secure, this process may also entail numerous authorizations and authentication steps being performed with each request by the Client CIM 102 to a Node CIMOM (for example, one provided on Node A 104, Node B 106 or Node C 108). These authorizations may also create delays in the processing of the request and the operating efficiency of the Cluster as a whole. Therefore, the approach shown in Figure 1 is often tedious and inefficient. This approach is often considered as operating at too high a level of abstraction and is therefore undesirable because of the burdens and inefficiencies it places upon the Client CIM 102 and the Cluster in general.

Another prior art approach often utilized to obtain information from Providers by a Client CIM 202 is shown in Figure 2. This approach again begins with the Client CIM 202 establishing a connection via a communications network 228 with another Node (for example, Node B 206) on the Cluster. However, unlike the example shown in Figure 1, for this embodiment only a single connection is established between the Client CIM 202 and a single Node (for example, Node B 206). In short, this approach does not require the Client CIM 202 to contact each and every Node on the Cluster. Instead, this approach utilizes Providers that are multi-node aware. One example of a multi-node aware Provider is provided in United States Patent Application Serial Number concurrently filed herewith, on August 31, 2001, by Jim Curtis, et al. and entitled "An Application Container that Allows Concurrent Execution on Multiple Nodes in a Cluster", the contents of which are herein incorporated, in their entirety, by reference.

As shown in Figure 2, this second prior art method requires each Provider to include a data daemon (for example, data daemons 230, 232, 234, 236, 238 and 240). Each data daemon contains the appropriate software codes such that when a request from

1 a single Provider (for example, Provider A 220 of Node B 206) is communicated to the
2 various other Nodes on the Cluster, each corresponding data daemon (for example, data
3 daemon A 230 on Node A, or data daemon A 234 on Node B 206, or data daemon A 238
4 on Node C) provides the requested information, when available. In this prior art
5 embodiment, every Provider, and thus every data daemon, must be Cluster-aware.

6 Noticeably, even the requesting Node (Node B 206) contains data daemons 234
7 and 236 from which configuration information may be needed. Further, this approach
8 requires each Provider to be capable of contacting other Providers on the Cluster. Since
9 certain applications may not provide Cluster-aware Providers, this approach may be of
10 limited applicability. Further, instead of having the Client contact every Node on the
11 Cluster, this approach merely reduces the decision/contacting processes to the Provider
12 level. Further, this approach requires every Provider to be capable of multiplexing
13 requests to every other Node on the Cluster. As such, this approach reduces the level of
14 abstraction to too low a level and requires every Provider to possess capabilities
15 previously provided by the requesting Client CIM, as shown in Figure 1. Therefore, a
16 new system and methodology for obtaining information from a Provider is needed which
17 does not place the burden for determining information about Resources on a Cluster at
18 either the Client CIM (i.e., too high of a level of abstraction) or at the Provider level (i.e.,
19 too low of a level of abstraction).

20 Summary

21 The present invention provides a methodology for collecting information from a
22 plurality of computers, on a Cluster, by utilizing a Multiplex Provider (MP). The MP
23 enables single-system CIM compliant OM Providers to be used, without modification, to
24 provide multi-node data from a Cluster(s). By utilizing the MP, a Client can connect to a
25 single Node on the Cluster and obtain information on several different peer Nodes, via a
26 Node CIMOM and an MP, without having to establish a direct connection to each Node
27 on the Cluster and without requiring every Provider to be Cluster-aware.

28 Further, the MP avoids putting the burden of multiplexing on either the Client or
29 the Provider writer. The Client requests multi-node data through a scoping hint that is
30 passed along with the request to a Node CIMOM. This scoping hint identifies those
31 Nodes from which the Client desires to receive the requested information. The Node
32 CIMOM suitably inspects the request in order to determine which classes/schemas of
33 objects are being requested and which Providers provide those classes/schemas. With the
34 MP mechanism, the Node CIMOM can also determine which classes/schemas should be

1 multiplexed, and utilizes the scoping hints to decide with which Nodes to open a
2 connection. In this manner, the MP effectively acts as a proxy for the Node CIMOM.
3 The MP takes on the role of a Client CIM (as discussed previously with reference to
4 Figure 1) by requesting information from other Nodes on the Cluster, while also
5 removing such tasks to a lower level of abstraction such that the Client CIM is not
6 directly contacting every Node on the Cluster with requests for information.
7 Additionally, in its requests to the other Nodes, the MP does not specify a scoping hint so
8 as to not trigger the MPs on the other Nodes to intercept the request. As such, by not
9 providing the scoping hints, a single set of data for the Cluster, from the desired Nodes,
10 may be provided to the Client by the MP.

11 In addition to streamlining the process for requesting data and alleviating the
12 burden from the Client and the Providers, the MP also provides data filtering capabilities.
13 Specifically, once the MP receives responses from the other Nodes, the MP gathers the
14 data, eliminates any redundant data, and provides the information (preferably in a tabular
15 form) back to the Client CIM which appropriately communicates the information back to
16 the Client. Further, the MP may also be configured to manage other related processing
17 steps, such as authorizations and authentications to remote Nodes.

18 As such, the present invention provides an improved methodology for obtaining
19 information from Resources on a Cluster. The methodology is preferably configured to
20 be implemented on a CIM environment, however, it may also be accomplished in other
21 environments, including, but not limited to, WBEM. The features and functions of the
22 present invention are further described in the drawing figures, the detailed description and
23 the claims.

24 **Description of the Drawings**

25 Figure 1 provides an illustration of a prior art method commonly utilized to obtain
26 information about Resources on a Cluster upon a Client's request.

27 Figure 2 provides an illustration of a second prior art method commonly utilized
28 to obtain information about Resources on a Cluster upon a Client's request.

29 Figure 3 provides an illustration of the process of the present invention wherein an
30 MP is utilized to obtain information about Resources on a Cluster upon a Client's request.

31 Figures 4A and 4B provide a flow diagram of the process by which the MP
32 obtains information from the various Nodes on a Cluster.

Detailed Description

As mentioned previously, the present invention utilizes an MP to obtain information on Resources, from Nodes on a Cluster, upon a Client's request. Unlike the prior art methods, the present invention does not require the Client to contact every Node on the network in order to obtain information about Resources available via the Cluster. Thus, the present invention alleviates many of the data connectivity and data obtaining tasks from the Client and shifts such tasks down to the MP, where they can be more easily implemented and with less Client to multiple Node communications being needed. It is to be appreciated, that by utilizing this approach the data traffic on the network 328 (see Figure 3) may be significantly reduced since every Client is not continually contacting every Node on the Cluster whenever Resource information is desired.

Additionally, unlike the prior art method shown in Figure 2, the present invention does not require every Provider to be Cluster-aware. Instead, the MP provides the needed Cluster-awareness. Since an MP is preferably loaded onto each Node, Providers that are not Cluster-aware may be suitably added to a Node while information about such Provider may be obtained from other Providers or Clients by the MP. As such, the present invention greatly simplifies the adding of Providers to Nodes, in that such Providers do not need to be or become Cluster-aware. The Cluster-awareness is preferably provided by the MP associated with each Node on the Cluster. Further, the present invention expands the possible number of Providers that may be utilized on a Cluster, because all that is required, in order to be "known" on the Cluster, is the ability to interface with the MP without requiring any capabilities to "know" of other Providers on the same or other Nodes.

Further, the MP approach of the present invention also provides enhanced update capabilities. Instead of having to update every Provider with Cluster information, as provided for with the embodiments shown in Figure 2, the present invention enables Cluster managers to only update the MP associated with a Node or multiple Nodes on the Cluster. It is readily appreciated that updating the MP on each Node is less extensive of an operation than having to update every Provider on a Cluster. Similarly, economies of scale realizations may also be experienced with regard to verifications, authentications, authorizations, and other processes which may need updating or augmenting. The present invention generally removes the target of such updates from the individual Providers and places it on the MP, thereby, further incurring savings in time and resources needed to maintain and/or operate a Cluster.

Referring now to Figure 3, one embodiment of an implementation of the process of the present invention is depicted. As shown, this embodiment utilizes a Client CIM 302 that has established a connection, via a network 328, with a Node (in this case Node B 306) on a Cluster 300. The Node 306 suitably includes a CIMOM 312 that includes an MP 334. The MP 334 is suitably connected via data links 330 and 332 to the various other Nodes (Node A 304 and Node B 308) on the Cluster 300. It is to be appreciated that such data links 330 and 332 may be same links utilized by the Node 306 to communicate with its peer Nodes or any other links. Further, the data links 330 and 332 may also be separate links, specifically configured for communications between MPs and the other Nodes on the Cluster and/or the CIMOMs associated with such other Nodes. Thus, any link between the MP and the additional CIMOM Nodes on the Cluster may be utilized by the present invention.

Further, the MP 334 communicates directly with the CIMOM on each Node (310 and 314, respectively), thereby alleviating the burden of such communications from the Client CIM 302 and/or the Providers (316, 318, 320, 322, 324, and 326). It is to be appreciated that each Node, in the preferred embodiment, includes an MP 334. As such, a Client does not need to connect to a specific Node in order to receive Resource related information that is obtained Cluster-wide, or for even a limited sub-set of a Cluster. However, the present invention may be configured in alternative embodiments, as desired, such that only specific Nodes contain the MP and provide the capabilities of requesting and obtaining information from the various Providers on the various Nodes, or specific Nodes, of a Cluster.

Referring now to Figures 4A and 4B (with reference to Figure 3), one embodiment of a process, by which the present invention utilizes an MP to obtain information on Resources associated with a Cluster, is shown. The process begins with a Client connecting to a Node 306 via a Client CIM 302 (Block 402). It is to be appreciated, that each Client is suitably configured with a CIM compatible interface that allows the Client to establish communications with a particular Node on the Cluster (for example, Node B 306, as shown in Figure 3). When connecting to the Node 306, the Client CIM 302 suitably performs those commonly known in the art tasks such as authenticating, verifying connectivity, and other such tasks.

Once the connection between the Client (via the Client CIM 302) and the Node 306 is established, the process continues with the Client sending a query to the CIMOM 312 on the Node 306 (Block 404). It is to be appreciated, that depending upon the

specific implementation of the process of the present invention, that a request may have to be specified in a particular format in order to be valid. One such format includes HTTP, but, the present invention is not so limited. Further, the query suitably contains a request(s) for information about either the Resources connected to the Node 306 and/or Resources connected to other Nodes (for example, Node A 304 and Node C 308) on the Cluster 300. At this point, the CIMOM 312 determines whether the query from the Client is a request for Resource information or a request for other information or services (for example, a request to lock-up a Resource) (Block 406). If the query is for non-Resource information or services provided by the Node 306, the CIMOM 312 processes the request using established procedures that are beyond the scope of the present invention (Block 407).

When the query is for Resource information, the CIMOM 312 suitably passes the query to the MP 334 (Block 408). The MP 334 then determines the scope of the query (Block 410). It is to be appreciated that a query from a Client may request information on every Resource on a Cluster, a limited type of Resources (for example, only information on disc drives), information on limited Resources as identified by specific Nodes, and/or based upon any other criteria. In order to determine from which Nodes a Client may desire to request information, the present invention enables a Client to request discovery on the Cluster 300 (Block 412).

When discovery is requested, the CIMOM 312, via the MP 334, suitably communicates a broadcast probe across the Cluster 300 (Block 414). The broadcast probe may be a general probe wherein, for example, every CIMOM Node (for example, Node A 304 and Node C 308, in Figure 3) identifies itself to the requesting CIMOM Node (Node B 306). Alternatively, any level of specificity may be utilized in requesting CIMOM Nodes and/or Providers (which, in certain embodiments, may even include those Providers connected to the requesting CIMOM Node) to identify their existence to the requesting CIMOM Node. For example, a broadcast probe might seek only those Providers that are connected to data storage Resources. Similarly, other broadcast probes might seek processors capable of performing specific operations. Thus, the broadcast probe may be for any topic and sent to any desired distribution of Nodes, Clusters, Resources, and/or Providers.

The requesting CIMOM Node (for this example, Node B 306) suitably receives replies from the responding CIMOM Nodes (e.g., Node A 304 and Node C 308) and compiles a table that includes a listing of such responses (Block 416). The CIMOM 312

1 and/or filters may also be utilized to sort, organize and/or present requested and received
2 information to a Client. Also, commonly known query languages and techniques can be
3 utilized to accomplish any desired filtering of received data, as desired by the Client or
4 Cluster manager.

5 Upon production of the tables by the requesting CIMOM, the process then
6 continues with the Client CIM 302 receiving the completed table (or, in certain instances,
7 portions thereof) and communicating such results to the Client (Block 430). At this point
8 in the process, the Client has then received the requested information.

9 At this point, the process ends (Block 432) until another request is generated by
10 the same or a different Client. As such, it is to be appreciated that the process flows
11 depicted in Figure 4 may occur simultaneously on multiple nodes of a network, when
12 such Nodes are suitably configured to operate in conjunction with an MP.

13 Therefore, the present invention has been described in the context of a process
14 flow implemented on a system that utilizes CIMS, CIMOMs, MPs and Providers to
15 communicate with, request and receive information about objects/schemas on a Cluster
16 without requiring Cluster-aware Providers and/or Clients that are capable of
17 communicating with every Node on a Cluster. Further, while the present invention has
18 been described in the context of specific embodiments and process flows, it is to be
19 appreciated that the present invention is not so limited and may encompass any systems
20 and/or process flows which are within the scope of the present invention as specified by
21 the following and any subsequently added claims.